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ABSTRACT

Noting that the realities of globalization are changing what as well as how and when students learn, this publication focuses on the bridge to higher academic achievement in writing through the use of technology. The information in the booklet is a foundation for improving teaching and learning of writing in the context of the Digital Age. Although a major purpose of writing instruction has been to teach students to communicate with text, the purpose is becoming increasingly expansive in terms of what constitutes text. The notion of text is coming to mean communication with a suite of tools and media, including written work, hypertext, graphics, and multimedia. This report is organized as follows: section one describes the complexity of the writing process; section two describes what leading researchers have found to be the best practices in effective writing; section three describes how the written media should be redefined to leverage the writer's visual intelligence; section four describes how conventional writing is affected by technology; section five presents examples of technology solutions in writing; and section six discusses future trends in the use of technology in writing instruction. (Contains 5 figures and 65 references.) (PM)

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Digital Age Learning

Given the realities of globalization, knowledge work, and accelerating societal change, it's obvious that *what* students learn—as well as *how* and *when* they learn it—is changing.

Technology plays multiple roles in education's transition into a system that effectively serves students destined for life in a knowledge-based, global society.

- **Technology is a driver of change.** Technology is the fundamental cause for societal shifts toward globalization and the new economy. Society now requires a highly educated populace that exhibits technological, visual, and information literacy in the context of critical thinking, cultural awareness, and social responsibility—skills for the 21st century. The bottom line is that schools must provide opportunities for students to develop these 21st century skills.

- **Technology is a bridge to higher academic achievement.** Research shows that when technology is used appropriately—in the context of sound learning theory—children learn more, even as measured by conventional tests. The key to identifying technology-based solutions that work is to synthesize three important areas of research:

    - Sound learning strategies in the content domain.
    - General learning theory from the cognitive sciences.
    - Technology-based learning approaches that research says work.

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Schools need to fully understand each of these three areas as they build programs that provide students with every opportunity to maximize learning.

- **Technology is a platform for informed decision making and accountability.** Technology systems are now available for tracking students' progress over time. The challenge lies in building such accountability systems based on the right indicators—indicators that lead to academic achievement *and* 21st century skills. When used effectively by educators who are competent with such tools, these formative assessments should enable teachers to provide students with learning experiences matched to their learning needs.

As John Bailey, U. S. Director of Education Technology, argues, "A lot of what we have to research are appropriate ways to use technology at various grade levels, in various subject areas" (Landry, 2002, p. 41). He believes "We're just now starting to get to the point where all the pieces are in place—hardware, connectivity, content, and training. It's difficult to measure something's effectiveness if it is only partly implemented" (Landry, 2002, p. 40).

This publication focuses on the bridge to higher academic achievement in writing through the use of technology. It is important to note that we don't start with technology. Rather, the publication provides an in-depth look into how rigorous, research-based learning theory on writing and how technology can augment, enrich, extend, and develop the student as an expert writer. As a foundation, it also acknowledges the increasing importance of visual imagery, multimedia, and communication as writing is redefined for the 21st century. **The authors recommend that educators use the information in this publication as a foundation for improving the teaching and learning of writing in the context of today's Digital Age.**

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Overview

The last three decades have seen enormous shifts in educators' and researchers' views about teaching writing. Traditionally, writing instruction focused on "product"—the mechanics, style, and quality of the text students were able to produce. In the past three decades, however, writing instruction has moved toward an equal, if not greater, focus on writing as a "process"—helping students understand and engage in the processes involved in writing (Harris et al., 1998).

Furthermore, although a major purpose of writing instruction has been to teach students to communicate with text[1], that purpose is becoming increasingly expansive in terms of what *constitutes* text. Until very recently, the teaching of writing has treated "text" as synonymous with the written word. Today, the notion of text is coming to mean communication with a suite of tools and media—including the written word, but also including hypertext, graphics, and multimedia. "Proficiency" in writing, therefore, must become equally expansive, including the ability to communicate not only through the written word, but also through other modes—visual or audio communication, for example—if these enhance message conveyance.

This report is organized as follows:

- Section One describes the complexity of the writing process and what writing entails for the student writer in particular. If one understands all of the cognitive activities in which writers engage, it is easier to envision how—and when—technology might be used to help students when they write.
- Section Two describes what leading researchers have found to be best practices in effective writing

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instruction. It is stressed throughout this document that no technology tool, program, or intervention is by itself a "sure win." Rather, technology interventions are only effective insofar as they are pedagogically sound. This section, then, lays the backdrop for effective uses of technology in writing instruction.

- Section Three describes how the written medium in today's world should be redefined to leverage the writer's visual intelligence.
- Section Four describes how conventional writing—written products, the writing process, and writing assessment has been—or can be—impacted by technology.
- Section Five presents examples of promising technology solutions in writing. These solutions were chosen because they highlight principles outlined in earlier sections.
- Section Six discusses future trends in the use and impact of technology for the teaching of writing.

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Section One: The Complexity of the Writing Process

Traditionally, educators have thought about writing as a fairly straightforward, step-by-step process in which writers move sequentially from a planning stage to a writing stage, and finally to a revising stage. But research demonstrates that this characterization tremendously underestimates the complexity of the writing process. A frequently cited model of the writing process, developed by Linda Flower and John Hayes (1981), describes it in the following way:

- Writers juggle a number of cognitive activities when they compose: They plan, generate, organize, evaluate, and revise not only text, but also goals for their text.
- Contrary to earlier thinking about the organization of these activities, all are carried out recursively, meaning that writers may stop what they are doing at any time and go back to revisit an earlier part of the process. In other words, writers do not proceed neatly from planning to drafting to revising. For example, a writer in the midst of writing a paragraph might decide that his argument will not appeal to a particular audience, and this decision may trigger an evaluation of previously generated text. This, in turn, may lead to revision of this text and to the generation of an entirely new goal.
- The backdrop for this activity includes what the writer knows (about his topic and about his audience), the specifics of his writing task, and the text that has already been produced. These factors impact what will happen at any given moment.

Because of the complexity of the writing task, it is not surprising that cognitive scientists view writing as problem

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solving (Bruer, 1993; Scardamalia and Bereiter, 1986). Problem solving generally involves tasks for which the problem-solver does not know the solution and for which the method of arriving at the solution is not specified. Writing—as a problem-solving task—can be even more complex. Unlike a math problem, many "solutions" might be acceptable, and the criteria for knowing when a solution does or does not work are not specified. Furthermore, a number of possible paths exist for arriving at a solution—but again, the effectiveness of any given path is not specified. These qualities make writing tasks ill defined in contrast to the well-defined problems one might encounter in mathematics.

Quoting Flower and Hayes, Bruer (1993) illustrates the complexity of the writing task as follows:

> *"When I started this book, my writing task... was a single sentence: Write a book on how cognitive research can contribute to educational reform.... I had to develop an initial representation of the task and use it to construct a writing plan. In my plan I had to make tentative choices about what to say, who my audience might be, and how to organize the content for that audience.... I had to make choices at every level, from what my gist was to the exact words I would use to convey that gist. Then, as I wrote and read what appeared on the page, I often had to revise my plan; I had to rethink and redefine my problem in the course of writing.... There are so many choices and so much latitude in making them that, as with other ill-defined problems, there is no single best solution.*
>
> *Writing is not like following a recipe, one step after another; it is more like being a juggler, an air traffic controller, or a short-order cook in a busy diner. A writer has to attend to many things simultaneously so that no ball, plane or pancake hits the ground. [...] Viewed in this way, a writer in the act is a thinker on full-time cognitive overload." (pp. 218-20)*

There is good reason to believe that the more novice the writer, the more weighty the task of writing (Thadani, 2000). For the expert writer, some lower-level aspects of the writing process may be more automated than for the novice writer, reducing some of the demand on cognitive resources. The expert writer may not have to worry, for example, about spelling or generating a grammatically correct sentence. As Hayes and Flower (1986) suggest, expert writers may have schemas—mental frameworks that help organize actions or responses—that make planning and generating content easier. For this reason, the expert writer can attend more easily to higher-level concerns such as content and organization. Beginning writers, however, must grapple with lower-level concerns, which can make the writing task even more demanding for them.

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Section Two: Best Practices for Effective Writing Instruction

Section One addressed the complexity of the writing process particularly for the novice writer. This section describes how writing instruction can best be structured to enhance students' writing experiences. The chart below summarizes the research-based thinking on effective, process-oriented writing instruction that follows (Flower & Hayes, 1981).

Summary of Best Practices

1. Writing tasks are rooted deeply in meaningful content that students have a chance to explore.
2. Students a) learn the value of and b) engage in writing as a process – including planning and revision across multiple drafts.
3. Students write for authentic audiences.
4. Students write for authentic purposes.
5. Students collaborate with others (teacher or peers) and have opportunities to incorporate feedback and reflect upon their work.
6. Students exercise some choice over their topic.

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7. Students write frequently and regularly.

8. The classroom environment is highly structured and predictable.

9. Higher level cognitive activities are scaffolded appropriately.

Process-Based Approaches to Writing Instruction. Donald Graves (1985), often referred to as the "father" of process writing approaches, states, "The writing-process approach to teaching first emphasizes what children know, then the conventions that will help them share their meaning with others in the class." According to a number of experts and researchers in the field (see, for example, Calkins, 1994; Graves, 1985; Baker, 2000; Harris et al., 1998; Peterson, 2001; Holbrook, 1984; Scardamalia and Bereiter, 1986), the following are qualities of effective, process-oriented writing programs:

- Effective, process-oriented writing programs help children discover and understand the content they want to communicate, and later to communicate that content using text. Inquiry learning is one means of providing students with opportunities to explore content that can later be the subject of their writing. Students work closely at exploring and understanding a data source; they work on writing skills in the context of communicating persuasively or descriptively about their topic.

- As the title implies, process-instruction focuses on writing *processes*, helping students engage in planning, goal-setting, drafting, editing, and publishing, helping them understand that texts take shape over multiple drafts and that revision and planning are important sub-processes.

- Students write for authentic audiences who will or can respond to what has been written, who can learn from what is written, and who have tangible opinions, knowledge, or interests. It is important to note that teachers and peers can serve as authentic audiences, as long as the writing is a genuine act of communication with these individuals. This condition serves a motivational function and it makes the feedback-revision process more effective. Through interaction with these audiences, the student can acquire information about what his/her writing needs to be more easily understood or persuasive. This process can help students learn to transition from what Scardamalia and Bereiter (1986) call "knowledge telling" (simply telling what one knows about a topic) to "knowledge transforming" (tailoring one's writing so that it addresses an audience and purpose).

- Writing assignments that provide authentic purposes appear to elicit better writing from students. Newmann and colleagues (2001), for example, examined writing assignments in Annenberg project classrooms; they

report that students who were given authentic learning tasks[2] outperformed their counterparts on tests of writing achievement. This benefit was observed for high-achieving as well as low-achieving students.

Furthermore, the National Assessment of Educational Progress (NAEP) conducted an in-depth study of a small subset of their 1998 testing cohort (Greenwald et al., 1999). Looking at approximately 200 classrooms, they collected examples of students' best writing and obtained detailed information about the assignments that were the basis for these samples. The researchers then attempted to describe how assignments differed in classes that had a large number of high- versus low-scoring writing samples. They conducted qualitative examinations of assignments that were the basis for these samples, and found that assignments in classrooms with more high-scoring writing samples (a) were rooted in specific and substantive content, (b) provided guidelines or scaffolds about organization and audience, (c) asked students to write for *authentic audiences and purposes*, and (d) attempted to build engagement (e.g., by giving students choice over aspects of their work) (Peterson 2001; Storms et. al., 2000).[3]

- Students collaborate with peers, teachers, or both, and are given opportunities to incorporate feedback and build on past work. As children receive feedback, particularly that which responds to the meaning of what they have written, the "response confirms for the writer that the text fits his/her intentions" (Graves, 1985).

  The Writers' Workshop is built around the principles of collaboration and feedback (Farley, n.d.). In highly collaborative, workshop environments, students share their work and provide and receive suggestions and feedback to and from their peers. The National Center for the Teaching of English (NCTE) provides detailed guidelines that should be followed during workshop activities (e.g., writers make no disclaimers or apologies for the work they share; workshop members provide feedback one at a time, in a pre-assigned order).

- Students are allowed to exercise some choice in topic and how they address that topic. Choice of topic, according to Graves (1985), serves as a vehicle for helping children learn to "know what they know" and provides a critical ingredient for engagement and motivation.

- Children are given frequent and regular opportunities to write. Time allows for both practice on skills used during the writing process and for these processes to be carried out meaningfully and with sufficient feedback from authentic audiences.

- Lest the phrase "process approach" suggest a free-for-all, with students doing what they please, Graves (1985) points out that the successful, process-oriented classroom is highly structured and predictable. He explains, "Predictability means that writing occurs daily, at set times.... Children learn to take responsibility not only for their topics, content of their drafts, and final copy, but also for carrying out classroom

decisions. A structured classroom requires an organized teacher who has set the room up to run itself." (Teaching Writing - Two Basic Principles section, ¶ 4)

- Scaffolding refers to the assistance that teachers (or more able others, in general) can provide to students to help them work through a problem and begin to engage in higher-level processes. Scaffolding can take various forms, including guiding questions that structure what information students pay attention to and prompts that remind students to reflect on their learning or evaluate their solutions with specific criteria. These processes are gradually internalized by students.

  Procedural facilitation is one instructional strategy based on the notion of scaffolding (Scardamalia and Bereiter, 1986). Developed to assist elementary school students with writing, the process involves providing them with supports (or scaffolds) that cue them to engage in higher-level cognitive activities. For example, students might be given cue cards (or computer prompts) that ask them to reflect on audience or purpose at various points as they write and revise. Scardamalia and Bereiter (1986) write: "Procedural facilitation appears to hold promise as a way of influencing the direction of attention during composing. We have seen evidence of transfer of facilitated procedures into unassisted composition..." (p. 796).

  Self-Regulated Strategy Development (SRSD), an instructional strategy developed by Stephen Graham and Karen Harris (1989), is another example that involves providing students with mnemonics that assist them with specific thinking strategies (note that this kind of support is one aspect of SRSD: the entire instructional approach is described in detail in Harris (1998). SRSD appears to have a large research base and has been effective in various contexts using different measures of growth in writing (Harris et al., 1998).

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Section Three: New Dimensions to Writing Through Visual Intelligence

The first two sections of this report trace the evolution of our understanding of the writing process and emerging best practices in the teaching of writing. This third section looks beyond the realm of current practice into emerging societal trends that impact both the definition of writing and the teaching of writing.

The digitization of voice, video, data, images, and words into packets of information has resulted in a convergence of what *were* distinct and separate venues for communication. Text messages now pop up on the displays of cell phones. CNN continuously runs a 'ticker tape' of news across the bottom of its TV displays. Phone calls can be placed over the Internet from your computer. Digital photos are embedded in e-mail messages. Pagers display charts, graphs, and even Web pages, in addition to words and numbers. Billboards have become digital displays and Web pages now stream full-motion video to the desktop. This new, visually-oriented culture calls for a populace of 'visually intelligent' writers—writers who are only skilled in the conventions of visual communication, but who use visual reasoning to read, write, and communicate.

Having 'gone digital,' today's society, in fact, has blurred the edges of writing and text to include visual explanations, visual images, charts, graphs, animations, manipulated images, animations, and full-motion video. In many ways this is a return to the Latin root for text, *texere*—meaning *to weave*—in this case, the weaving of multiple forms of communication together digitally.

For the writer—and the teacher of writing—this presents challenges and opportunities: challenge in mastering the genre of visual imagery in combination with the written word; opportunity in anchoring a reader in a visual context that leads to a deeper understanding of the written expression. Today's reader expects to see visual

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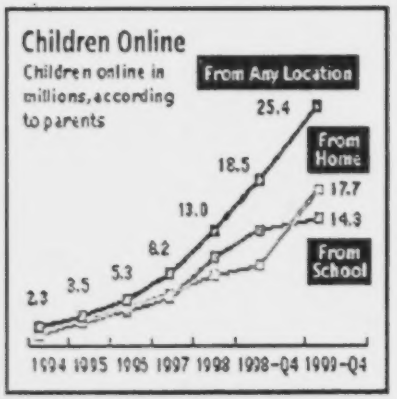
imagery that adds context, explanation, and depth to a communiqué. If a writer is to communicate effectively with such an audience, this visual aspect cannot be ignored. In fact, visual imagery brings the following new dimensions to reader-based writing:

- **Visual Explanations.** Visuals provide the opportunity to combine text, graphics, and images in ways that enable the reader to 'see' the story the writer is trying to convey. Consider, for example, the following paragraphs. The first uses words only to convey meaning, while the second demonstrates how visual explanation adds to the reader's understanding. In fact, one wonders if the text is superfluous once the graphic is introduced.

Children Online

A significant threshold was reached in children's access to the Internet in late 1998. The graph at the right indicates that, prior to 1998, more children had access to the Internet from school than from home. But in that last quarter of 1998, parents reported—for the first time—that more children had access to the Internet from home than from school.

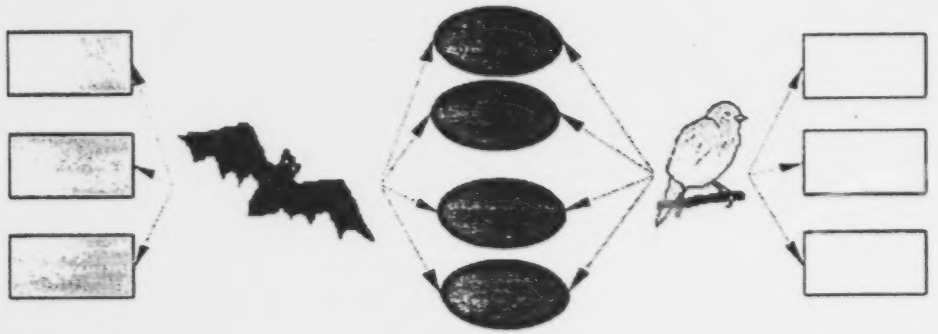


(Figure and text reprinted with permission from Grunwald Associates. (2000). Children online. In *Children, families, and the Internet 2000: Study overview*. Retrieved January 10, 2003 from http://www.grunwald.com/survey/survey_content.html ©2000 Grunwald Associates. All Rights Reserved)

- **Clarity through association.** Students can also use visuals to organize their thoughts—to make their thinking visible. This can be a powerful asset during prewriting activities as well as for the final product. For example, consider the inclusion of this graphic in the report two students, Margaret Belanger and Judy Mayes, from Yorktown Heights, New York, are presenting on bats and birds. The differences and

similarities between the bats and birds are strikingly clear when mapped in this simple graphic using Inspiration® software.

How bats and birds are the same and how they are different



(Reprinted with permission from Inspiration Software, Inc. (2002). Figure: How bats and birds are the same and how they are different. In *Inspiration Software, Inc. product resource guide*. Portland, OR: Author. © 2002 Inspiration Software, Inc. All Rights Reserved.)

In his 1983 book, *Frames of Mind*, Howard Gardner outlined seven different types of intelligences, including linguistic and spatial intelligences. He conjectured that adults had varying degrees of facility with all seven and that sophisticated adults meld several together at any given time. Thus the writer's use of visuals and words in concert engages the readers' multiple intelligences.

As emphasized in *How People Learn*, published by the National Research Council, learning is predicated on prior knowledge (Brandsford et al., 2000). People come to our formal education systems with knowledge, experiences, beliefs, and understandings that can help or hinder comprehension. Anchoring writing in a common experience through visuals creates a context of common knowledge enhancing the depth of understanding by the reader.

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Section Four: Technology and the Teaching of Writing

Earlier sections of this report described best practices in writing instruction as well as the impact of technology, especially visual media, on writing conventions. This section brings these ideas together and explores how writing instructors can leverage technology to enhance what and how students write. The following brief overview of past research demonstrates that, indeed, technology does affect students' writing both in terms of process and product. The second part of this section explores the many ways in which teachers can use technology to facilitate instructional practices described earlier and enhance students' writing processes and products.

What the Research Says. Research has demonstrated that, at minimum, access to computers can impact *how much* students write or revise. According to Cochran-Smith's (1991) review of research, studies have found that students who have sufficient keyboarding skills tend to write longer texts with a word processor than with paper and pencil; this finding does not hold, however, for students whose keyboarding skills are limited. Furthermore, studies have also found that students write more frequently or stay on a single writing task for longer periods of time when using word processors relative to paper and pencil. Cochran-Smith (1991) is careful to point out that longer texts are not necessarily better; however, they may suggest either that teachers are structuring writing tasks differently when using technology or that students' attitudes about writing is more positive.[4]

Work by Owston and Wideman (1997) compared students in classrooms with a 3:1 student-to-computer ratio (the "high access" group) with those in classrooms with a 15:1 ratio (the "low access" group). The former allowed students greater opportunities to write with the computer than the latter, and although students in both groups wrote with similar overall frequency, high-access students tended to write longer texts (as measured by word counts) than low-access students.

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Cochran-Smith (1991) also reported that students tend to revise more frequently when they compose with word-processors than with pencil and paper. Again, although these revisions do not necessarily improve the quality of text in the absence of other interventions, they may point to an increased willingness to revise, perhaps because of the mechanical ease of doing so.

Finally, research in the late 1980s and early 1990s by the Apple Classrooms of Tomorrow (ACOT) group suggests that technology can profoundly impact the text students produce, how they produce it, and the ways they come to think about what text is. Tierney (1996) writes that at onset of the ACOT project:

> *"Most students approached texts in a rather limited fashion. They would proceed with little regard to integrating graphics or other media, layout would be largely predetermined and conventionalized, text would be rather linear and non-layered, and audience was considered somewhat as an afterthought. In accordance with this tendency, computers were perceived as tools for expediting revision to ensure accuracy.... But by years three and four, student involvement with multimedia became more prevalent, especially via HyperCard. And, in turn, major shifts occurred. Accompanying the shift to multimedia was the unearthing of a new, more powerful set of genres and text forms. With these texts, students seemed less verbocentric. They were more likely to include graphics and appeared to display a greater willingness to experiment.... Their developing understanding of technology altered how students used symbol systems (that is, graphics and print) to explore, represent, and share ideas." (pp. 173-174)*

The Value Added through Technology. While the research above captures some of the ways in which technology can affect students' writing, this section draws on a variety of resources, beyond "impact" studies to explore more fully how technology can support teachers' and students' efforts with this skill. Section Two of this report described best practices in writing instruction. The table below summarizes how technology can facilitate these practices. It is followed by a detailed discussion of how technology can potentially contribute to the product and processes of writing. Bearing in mind that technology-supported writing instruction is likely to be most effective if it is congruent with sound pedagogy, it is argued that:

- Technology can change the scope of *what* is viewed as "text" (the written product).
- Technology can fundamentally change *how* writers approach the writing task ange *how* writers approach the writing task (the writing process).
- Technology can impact *how well* writers are able to perform on a writing task.
- Ultimately, technology impacts *who* we view as strong writers; the skills that tomorrow's (if not today's)

strong writer possesses may have to be more expansive than they were traditionally.

Summary of Best Practices	Examples of How Technology Can Facilitate These Practices
1. Writing tasks are rooted deeply in meaningful content that students have a chance to explore..	• Technology can provide rich access to content in any subject area. • Communication technologies can facilitate students' discussion—and therefore their understanding—of that content.
2. Students (a) learn the value of and (b) engage in writing as a process—including planning and revision across multiple drafts.	• Technology can facilitate the mechanics of planning and editing. • Communication technologies can facilitate exchange of work, as well as collaboration and feedback among writers and/or instructors, providing direction for revisions based on readers' responses to a text. This process can help students transform what Flower (1979) calls "writer-based prose" into "reader-based prose"—text that addresses authentic audiences and purposes.
3. Students write for authentic audiences.	• Publishing software and the World Wide Web can provide the means for sharing work with real audiences. • Communication technologies can provide access to audiences, including experts, with whom writers can share their work. • Communication networks enable students to work on projects collaboratively with peers from other classrooms and schools. When these projects involve inter-classroom teams, students often rely on written communication as a means for sharing ideas, again providing them with opportunities to write for

audiences that will offer feedback.

4. Students write for authentic purposes.
   - Publishing software and the World Wide Web can provide the means for sharing work with real audiences.
   - Communication technologies can provide access to audiences, including expert resources, with whom writers can share their work.
   - When students work collaboratively on projects that involve inter-classroom teams, written correspondence serves the highly authentic purpose of communicating ideas to one's teammates.
5. Students collaborate with others (teacher or peers) and have opportunities to incorporate feedback and reflect upon their work.
   - Communication technologies can facilitate the exchange of work, as well as collaboration and feedback among writers and/or instructors.
6. Students exercise some choice over their topic.
   - Writers can use technology to find and access content that is personally relevant.
7. Students write frequently and regularly.
   - Note: This condition has to do with classroom culture; technology will only play a role here insofar as it facilitates the writing process and enhances motivation.
   - When students work collaboratively on projects that involve inter-classroom teams, there is often an expectation of regular written correspondence between team members to address project goals.
8. The classroom
   - Note: This condition has to do with classroom culture,

environment is highly structured and predictable.	and technology will only play a role insofar as it is integrated into the day-to-day routines of the classroom.
9. Higher-level cognitive activities are scaffolded appropriately.	• Technology can be used to provide prompts that scaffold composing processes. • Communication technologies can provide access to real audiences whose responses offer cues about issues a writer might address in his/her work.

'What': The Impact of Technology on the Notion of Text
Today's teachers can (and sometimes must) expect—and accept—a different type of product when technology is used during the writing process. In contrast to printed text, electronic text:

- **Offers new genres and conventions for writing**, especially in terms of electronic communication or Computer-Mediated Communication (CMC). These new forms include e-mail, threaded discussions, chat rooms, instant messaging, and other new forms of communication, and they have rules and conventions uniquely their own. Steven Marcus (1995) of the South Coast Writing Project in California writes: "Writers, researchers, teachers, and just plain folks have been noticing that words produced in e-mail settings seem to be a sort of hybrid, a combination of print and speech, for which standards and practices are still evolving" (p. 26). The author further points out that the social context of this form of communication differs markedly from other, existing communication modes: "No one would ever send a one-line letter by Federal Express [nor by regular "snail-mail" either, for that matter], but short e-mail responses are the norm. It's hard to imagine letting 2,000 people in on your correspondence with someone, but it happens with e-mail all the time" (p. 26).

- **Does not adhere to a linear, sequential organization.** Instead, electronic written products can often be explored in an order chosen by the reader. Hill and Mehlenbacher (1996) write that, "Since readers may be taking any number of paths through a text, writers need to anticipate what paths they may take, and design their texts so that any number of paths will result in a coherent reading" (p. 261).

- **Can fuse graphics, video, audio, and the written word to make a message more vivid or compelling**. As Barry (1997) so succinctly points out in *Visual Intelligence*, "...images plunge us into the depth of experience itself" (p. 75).

These changes in conceptions of text are reflected in the National Council of Teachers of English's (NCTE)

standards for English Language Arts. Standard 6, for example, states: "Students apply knowledge of language structure, language conventions (e.g., spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and non-print texts" (NCTE, n.d.). Teachers who take these more expansive views of text build more than their students' ability to communicate flexibly. They also help students develop a host of other critical proficiencies such as visual and technological literacy, and the ability to use real world tools.[5]

'How': The Impact of Technology on the Process of Writing

Existing research on writing has demonstrated repeatedly that the writing processes of skilled or seasoned writers are markedly different from those of beginning writers. Skilled writers plan more, they revise more—and at deeper levels (e.g., organization or meaning), and they address the needs of their audience more effectively (see Flower, 1979; Scardamalia and Bereiter, 1986; Bruer, 1993; Thadani, 2000). Technology tools can be used to make the mechanics of planning or revising easier; they can be used to provide access to real, sometimes expert audiences who can provide students with feedback on their work, and they can be used to scaffold aspects of the writing process that pose the greatest difficulty to novice writers. A number of authors have described ways in which technology can impact the writing process.

Technology can facilitate revision. Arguably, technology has had its most profound impact on revision processes, which have implications for other aspects of writing. For that reason, impact on revision is described first.

Clearly, editing is far easier with the computer than it ever was with paper and pen or typewriter. Consider the following excerpt from Sharples' (1998) book, *How We Write*

> *"The computer has...[separated] the text from the page....Writing on a computer has become a seamless combination of adding and deleting....No longer does a writer need to make a judgement [sic] about whether to*

The following Web sites illustrate how much the notion of text has changed as a result of technology:

The first example by *National Geographic*, (www.nationalgeographic.com/egypt/), was featured in a recent article by Mike Sharples of the University of Birmingham in the United Kingdom. According to Sharples (1999), it is:

> *"An imaginative attempt at creating a dynamic story on the Web.... It takes the form of an interactive edition of the February 1923* National Geographic *magazine, giving an eyewitness account by Maynard Owen Williams of the discovery of Tutankhamen's tomb. The story is presented both as a simulated magazine and as a "silver screen" movie of the discovery. In one section, the same story is told from three viewpoints: Williams's official written account of the event, a series of photographs taken by Williams, and the*

> *embark on another draft. Having written on a computer for over 20 years, I find it hard now to recall the painful decisions I once had to make of whether to type out another complete draft, to send a page to a teacher or supervisor with crossings-out and insertions, or just to submit a poor draft as finished work."* (p. 189)

Cochran-Smith (1991) reports that writing electronically makes it far more feasible to revise at any point during the writing process. As a result, the line between one draft and the next blurs, and the notion of a "first draft" becomes murkier.

Research that compares expert and novice writers shows that novice writers revise less or revise more superficially than experts. In her classic paper on "writer-based prose," Flower (1979) argues that expert and beginner writers alike first produce text that is not organized or articulated adequately enough for a reader; hence, it is "writer-based." However, she argues, expert writers take what they initially produced and transform it for the reader—thus, rendering it "reader-based." Beginning writers, conversely, do not sufficiently engage in this process.

It should be noted that technology by itself does not result in students transforming writer-based prose to reader-based prose. Researchers have observed that students working on computers tend to revise *more*; however, these revisions are not necessarily for the better without some sort of instructional intervention (Cochran-Smith, 1991). However, teachers might exploit the ease of electronic editing to encourage student writers to revisit their texts in meaningful ways, adding explanations, reorganizing ideas, explaining their reasoning, or defending against counter-arguments. Furthermore, built-in spell- and grammar-checking tools, as well as thesauri, can be used to encourage beginning writers to temporarily put aside lower-level concerns (e.g., about grammar and spelling) and focus more of their attention on the messages they want to convey.

> *letters that he sent to the editor of the*National Geographic."

The second example, described in Monsef's (2002) article titled "Students find their voices through multimedia," was developed by high school student Consuelo Molina and is featured on the George Lucas Educational Foundation (GLEF) Web site (http://glef.org/index.html). The student's Web video on sweatshops, called *A Sacrifice for You*, is some ways even more compelling than the first because it is a student's attempt at dealing with an important social issue. *A Sacrifice for You* integrates video, audio, and text to address the topic of sweatshops. The written components of this piece—though not in traditional essay form—are carefully crafted and no less integral than the graphics for conveying the piece's powerful message.

Together, both pieces illustrate:

- How technology has transformed traditional conceptions of writing from something linear, static, and based largely on the written word into something nonlinear and dynamic, merging audio and video with the written word.
- How skill in writing today can (and must) be viewed as an ability to convey meaning not only with words, but with whatever strategies (visual, audio) best communicate a message.

Technology can facilitate how students plan and grapple with content. Two strands of work have bearing on the way technology can be used to help students understand a topic and plan for a writing task. The first body of work has found that concept mapping can help students understand and remember content (Ritchie and Volkl, 2000; Anderson-Inman and Ditson, 1999).

The second strand of work speaks to the importance of planning during the writing process. For instance, the U.S. Department of Education reports that, when taking the writing portion of the National Assessment of Educational Progress (NAEP), students who engaged in "visible planning" (on blank sheets of paper provided in test booklets) scored higher than those who did not. In addition, students who reported that their teachers required them to plan their writing scored higher on the test than students who reported that they were not required to plan (U.S. Department of Education, 1999).

Flower and colleagues (1989) write that student writers tend to plan less effectively and less often than expert writers. It follows then, that technology tools that help students understand what they do and do not know, and that help them organize that knowledge can facilitate the writing process. A number of software tools—such as Inspiration Software, which serves as a visual thinking tool for sixth-graders and older students—can serve these functions.

Anderson-Inman and Zeitz (1994) describe the benefits of electronic mapping software (as opposed to pencil-paper mapping or outlining) for planning and organizing. According to these authors:

- Electronic maps or organizers are "globally expansible," meaning that ideas are not limited to the length and width of a sheet of paper (Anderson-Inman and Zeitz, 1994, p. 21).
- Electronic maps or organizers are "infinitely modifiable," meaning that revising them is far less cumbersome than revising a paper version (Anderson-Inman and Zeitz, 1994, p. 21).
- Links make relationships between ideas far more explicit than they would need to be within an outline. According to Anderson-Inman and Zeitz (1994), "In contrast to the outlining process, where little organization is necessary until all the information is gathered, concept mappers are constantly looking for relationships and trying to depict those relationships graphically." (p. 24)

Figures 1 and 2 below from Anderson-Inman and Zeitz (1994) provide examples of how one student's knowledge, as well as the organization of that knowledge, evolves as he/she gathers information for an essay on cheetahs. These c) help students identify misconceptions, b) raise questions where knowledge appears under-developed, and c) provide students with feedback about content and organization.

Figure 1: Concept Map - Early in the Planning Process

Figure 2: Concept Map - Later in the Planning Process

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Technology can facilitate collaboration, feedback, and publishing. Not only can outlines, drafts, or even in-progress ideas be transmitted easily using technology; MacArthur (1996) also points out that the visibility of text on screen can make it easier for writers to interact about their writing. Furthermore, Computer Mediated Communication (CMC) affords new opportunities for writing instruction (Marcus, 1995). To begin with, CMC is in itself a written medium; thus, it provides students with frequent and easy opportunities to write. Second, because students are always writing *for others*, this forum makes very visible and very explicit *who* one's audience really is. Put another way, the CMC necessarily includes an authentic audience that students deal with actively. As a result, through responses they receive, students are provided with feedback on the clarity of their writing—for example, when the recipient of a message voices confusion or asks for clarification (Ware and Murar, 1998). Third, CMC makes it possible for students to access an audience of experts (e.g., professional writers and scientists, politicians)—something that has in the past been a far more complicated enterprise. Finally, technology makes a professional-quality publication not only possible, but far easier than ever before (MacArthur, 1996). As a result, student writing can serve authentic purposes as never before (Bracewell et al.,

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1998); students can create illustrated and printed books, Web pages, or communications targeted for authentic audiences.

Technology can scaffold writing processes. Technology can be used to scaffold writing processes, for instance by helping students understand and organize their ideas, cueing them to revise at higher levels, or prompting them to reflect on their audience's reaction to their writing. MacArthur (1996) reports that such prompting can help students improve the quality of their writing and the degree to which they revise. Scardamalia and Bereiter (1986) suggest that, "To be useful as procedural facilitations, computer software must induce mental processes that are not only of a higher level than those students normally employ but that can also have an influence on students' normal composing processes" (p. 797).

'How Well': The Impact of Technology on Students' Writing Performance

Technology can impact assessment of student writing. Once students become accustomed to using technology, in particular for writing, its availability (or lack thereof) has a bearing on student performance. Researchers have reported that students who are: (a) accustomed to writing on a computer and (b) have reasonable keyboarding skills are placed at significant disadvantages when they are asked to write without computers (Russell, 2000). Studies have observed that in these instances, students' performance on writing assessments is significantly higher when they are allowed to use computers. Although not established empirically, it would follow, then, that students who are accustomed to using a wide range of technology tools—such as the Internet for researching a topic and communicating with experts in the field, mapping software for organizing ideas, and communication technologies for exchanging ideas and garnering feedback—might be at a disadvantage when asked to work on writing tasks without these tools. Put a different way, when students are accustomed to technology as a tool, completing the same tasks without the tool may place them at a serious disadvantage. These findings imply that, not only teachers, but also schools, districts, states, and national testing boards, must take into account how students typically write, and what tools they have available to them when they administer writing assessments.

'Who': Revisiting the Notion of the Strong Writer

Consider NCTE's (n.d.) Standard 8, which states that, "Students use a variety of technological and information resources (e.g., libraries, databases, computer networks, and video) to gather and synthesize information and to create and communicate knowledge." Shifts in what constitutes text and how writers might use technology to enhance the writing process suggest that the "new" strong writer might possess a set of skills additional to those a "traditional" strong writer possesses. Consider Consuelo Molina's sweatshop piece (Monsef, 2002). This student clearly applied visual, technological, *and* traditional writing skills in delivering her message. Given the tools available today, and the many modes of communication writers can use to achieve their purposes, the "new" strong writer may evolve as the individual who can use formatting to make his/her argument more persuasive,

hypermedia to illustrate contrasting points of view, e-mail to collect expert points of view on his/her topic, or a variety of electronic publication formats to communicate his/her message.

The ease with which technology can be used to access, modify, and publish work also has implications for new understandings writers must develop about the social and ethical impacts of technology use. In other words, a writer must be highly informed and thoughtful about his/her responsibilities with regard to proper and ethical use of available tools. He or she must be able to address the following issues: How does one appropriately credit information from the Web? What are the ethics of digitally altering photographs or video for use with one's work? How do copyright issues impact reproduction of work posted online? The *enGauge® 21st Century Skills* framework (Lemke, n.d.), describes some of these issues student writers must consider when using technology to communicate ideas.

Digital Age Learning | Overview | Section 1 | Section 2 | Section 3 | Section 4 | Section 5 | Section 6 | Notes | References

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enGauge Resources

What Works—Enhancing the Process of Writing Through Technology: Integrating Research and Best Practice

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Section Five: Examples of Promising Technology-Supported Solutions

While the previous sections described ways in which technology might impact the teaching of writing, this section describes specific technology-supported solutions—either promising practices or resources—useful in the teaching of writing. As in Section Four, Section Five looks at solutions that address:

- What counts as "text" (the written product).
- How students tackle the writing process.
- How *well* students write when they become accustomed to using technology.

Throughout this discussion, it should be clear that teachers who effectively use technology to help students build their writing skills are, in the process, also building 21st century skills such as visual and technological literacy, collaboration skills, and self direction. In essence, when students use a range of available technology tools to write, they acquire more than the ability to communicate with words alone.

Some additional points are worth noting: Although an attempt is made to categorize solutions as impacting one or another facet of writing (e.g., revision, planning, and audience), it will become clear that many of these solutions represent *multifaceted programs* that address more than one issue—particularly, if teachers implement them within a coherent instructional framework. Thus, it is important to stress again that the impact and the shape of *any* given solution in the writing classroom depends, as Cochran-Smith (1991) argues, on the following: how teachers "interpret" the solution, the social context of the classroom, and teacher and student goals.[1]

This point is particularly important to bear in mind as one considers the research, described below, documenting

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the impact of these programs. Such impacts are generally observed under specific conditions, and as such no one of these solutions can be designated as "proven" (hence, our use of "promising" instead). In other words, in the same manner that a surgeon's instruments are only as good as the skills of the surgeon, ultimately, the success of these programs will depend on the skills of the teacher who implements them, as well as student and school characteristics. At the same time, even when a particular solution has not been directly researched (i.e., no attempt was made to gauge impact on achievement or writing proficiency), it was selected if it was in line with what educational researchers and theorists hold to be true about effective teaching and learning.

Each solution/program description below is organized into the following sections:

- Program name and Web site/contact information (if available).
- Program description.
- The value the solution's technology adds to teaching and learning.
- The program's link to best practices.
- A list of 21st century skills and proficiencies the solution may foster.
- Evidence of impact, including "first-" and "second-order" evidence of such impact. The former indicates that a direct program evaluation was conducted, whereas the latter links the solution to related research and best practices.

A word on evidence. The first- and second-order evidence used to assess each program or solution falls into one or more of the following categories. For each promising solution identified, the nature of the evidence reviewed will be categorized, described, and rated according to the designations in the chart below.

Nature of First- and Second-Order Evidence Cited[7]

Experimental or Quasi-Experimental (i.e., involves control or comparison groups)

Meta-Analysis

Summary or Review of Empirical Work

Non-Experimental, Quantitative (includes correlational research)

Qualitative or Descriptive Research - not quantified (includes interview responses, case studies, and evaluation findings, where data has not been

coded for quantitative analyses)

Field-Based Practices, Testimonials, or Action Research (conducted by teachers within their own classrooms)

Strength of Evidence - Rankings

- Strong
- Good
- Preliminary

The Little Planet Literacy Series™ : www.sunburst.com/littleplanet/index.shtml

Program Description

This is a multimedia program, developed by researchers at Vanderbilt University, targeting Grades K-1. Instruction is "anchored" in a single story presented on video. According to the series Web site, "The story includes authentic themes: finding the truth, not going along with the crowd, and standing up for your beliefs. The complex video story stimulates high level questions, sustains discussions, and encourages explorations of the story over a period of many weeks." After watching the video, students are given numerous opportunities to grapple with content before they write. They view the story on video or CD-ROM, read from a text, and then write their own versions of the story. The program allows students to publish their stories with pictures and musical clips for each page.

Value Added Through Technology

- Technology provides students with very concrete content that serves as the basis for writing tasks.
- Technology enables students to generate texts that integrate multiple modes of representation.
- Technology enables students to publish their work easily, increasing the authenticity of their writing tasks.

Links to Best Practice

- The video provides an authentic purpose for writing.
- Writing tasks are deeply rooted in meaningful content that students have a chance to explore.

21st Century Skills and Proficiencies Fostered

- Visual literacy
- Technological literacy

Evidence of Impact:

Order of Evidence	Nature of Evidence	Strength of Evidence
First	Experimental or Quasi-Experimental	Good

Researchers from the Cognition and Technology Group (CTG) at Vanderbilt University have assessed the impact of the Little Planet Literacy Series™ on students' writing skills. In a summary of their study, they report that, both writing fluency (number of words and sentences) and story complexity were higher for students in the program compared with students in a control group (Cognition and Technology Group, 1997). The summary report states that teachers participating in the project were provided with professional development from Vanderbilt researchers, but it is not clear whether teachers in the control group received equivalent (or any) support from CTG. Thus these results should be interpreted somewhat cautiously, as it is possible that they can be explained by the increased support given to teachers in the Little Planet program.

Other research by CTG also suggests that the program can impact student skills. In a summary of their early studies (Cognition and Technology Group, 1993-1996), the researchers' report that the writing activities included in the Little Planet Literacy Series™ can help students understand story content. They showed children, classified as having low and high-verbal skills, a video and found that when low-verbal children participated in the Series activities, such as story sequencing and bookmaking, their comprehension and discussion of the video increased to the level of high-verbal students. Again, the summary report does not provide sufficient information about the research methodology; thus, results should be treated cautiously. However, deep exploration of content is an important aspect of the writing process that the Little Planet Literacy Series does appear to foster.

University of Chicago Laboratory School's Photo Technology Class:
www.ucls.uchicago.edu/projects/2001-2002/PhotoTechnologyFall2001/about.html

Program Description

As part of an assignment for their PhotoTechnology class, 8th graders at this school created a Web exhibition of photos coupled with original creative writing pieces. In doing so, they used a number of real world technology

tools such as digital cameras, scanners, graphics editing, and Web publishing software. The online exhibition speaks to students' thought, effort, and skill in putting together this work.

Value Added Through Technology

- Technology enables students to generate texts that integrate multiple modes of representation.
- Technology enables students to publish their work online, increasing the authenticity of the task.

Links to Best Practice

- Students write for authentic purposes.
- Students exercise some choice in the work they produce.

21st Century Skills and Proficiencies Fostered

- Visual literacy
- Technological literacy
- Effective use of real-world tools
- Creativity
- Risk-taking

Evidence of Impact:

Order of Evidence	Nature of Evidence	Strength of Evidence
Second	Non-Experimental, Quantitative	Strong

Although no first-order research exists on this program, student products (UCLS, 1999) are impressive in scope and quality. Furthermore, work by Newmann et al. (2001) suggests that authenticity, including personal value or relevance, can foster student learning.

San Fernando High School: www.apple.com/education/k12/imagine/0203/sanfernando/profile/storytelling/

Program Description

Students at San Fernando High School use multimedia coupled with writing to convey their understanding of content area topics. Social studies teacher Marco Torres, featured on Apple's Web site as an Apple Distinguished Educator, is an excellent example of the way technology can be used in a content-rich, process approach to helping students communicate their ideas. First, Torres connects class topics to students' own experiences, enhancing the personal relevance of these topics. Students then conduct research and gather information (including by video), storyboard their ideas, collaborate, and provide feedback about content and message, create and edit electronic products that integrate video with text, and share their work with parents, peers, and community members.

Value Added Through Technology

- Technology enables students to generate texts that integrate multiple modes of representation.
- Technology enables students to publish their work online, increasing the authenticity of the task.

Links to Best Practice

- Students write for authentic purposes.
- Students write for authentic audiences.
- Students engage in processes of planning and revising.
- Students receive feedback and opportunities to incorporate that feedback.
- Students exercise some choice in the work they produce.

21st Century Skills and Proficiencies Fostered

- Visual literacy
- Technological literacy
- Effective use of real-world tools
- Creativity

Evidence of Impact:

Order of Evidence	Nature of Evidence	Strength of Evidence
Second	Non-Experimental, Quantitative	Strong

Although no first-order research exists on this program, student products (Apple Computer, Inc., 2003) are impressive in scope and quality. Furthermore, work by Newmann et al. (2001) suggests that authenticity, including personal value or relevance, can foster student learning.

Software That Facilitates Mapping and Planning Writing Content:

Program Descriptions
A number of educators have noted the value of planning and brainstorming software (Anderson-Inman and Ditson, 1999; Scott, 2000; MacArthur, 1996; Kight, 1998).

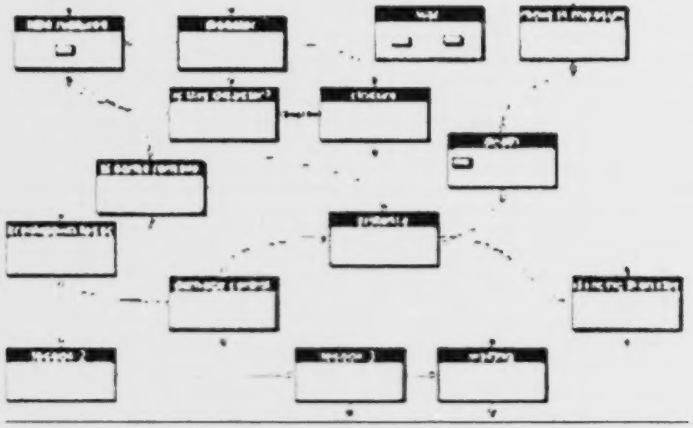
Inspiration® Software (or **Kidspiration™**, for younger children) is an example of software commonly used for concept mapping and brainstorming. The program can be used to electronically produce maps, diagrams, flow charts, etc., and these can be transformed into more traditional outlines (Scott, 2000). Kight (1998), who has used the software to work on writing skills with learning disabled children, believes that because beginning writers do not plan as much as experienced writers, this kind of software can help students organize their ideas before they begin writing. According to Anderson-Inman and Horney (1997), as cited in Anderson-Inman and Ditson (1999), "If used before writing, brainstorming can help students generate ideas to explore as they write or identify sources of information about an assigned topic" (p. 9).

Flashes, a newsletter printed by the Inspiration Software publishers (2002), features uses of the software by teachers. In one example from May 2002 newsletter, high school teacher Sue Erichsen uses Inspiration in the context of teaching about Mark Twain's *The Adventures of Huckleberry Finn*. Note that the software is used not as an isolated activity, but in the context of process-oriented instruction. According to the newsletter:

> *"During a six-week unit, students read each chapter in the book and brainstorm about Huck's experiences. In small groups they create a graphic organizer depicting each of Huck's worlds and then discuss them as a class.... 'To be able to write rich essays, students must get a good handle on the works they've read and the various literary elements that make up the work,' says Erichsen. "Creating maps of the literary elements helps the students effectively compare and contrast Huck's various worlds." (p. 3)*

Storyspace software, available at www.storyspace.net/outline.html, developed by Eastgate Systems, Inc., can also be used to facilitate planning (Crain et al., 1993). Storyspace is a hypertext software that provides authors with "writing spaces" that can contain text (large amounts, if the writer desires), graphics, video, and audio. Writing spaces can be linked in many different ways (e.g., hierarchically) and links can be reorganized as the writer chooses. Jeanie Crain, an instructor who has used Storyspace as a prewriting tool in her classes, writes that the software is "A tool for collecting, organizing, and expressing complex thoughts" (Crain, 1993).

The following schema depicts an example of the Storyspace interface. "Writing spaces" are represented by boxes; links between spaces are easily reorganized.



(Figure reprinted with permission from Crain, J. C., Abels, M., Ibrahim, S., Keefhaver, B., Matthews, S., & Staton, M. (1993). Courseware review: Storyspace hypertext writing environment. *Computers and the Humanities*, 27(2), 137-141. Retrieved November 13, 2002, from http://www.eastgate.com/storyspace/chum/chum.html Storyspace Hypertext Writing Environment © 1987-2003 Eastgate Systems, Inc. All Rights Reserved.)

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Value Added Through Technology

- Software can be used to help students explore content.
- Software can be used to help students plan and revise.

Links to Best Practice

- Software facilitates organizing knowledge and planning for writing.

21st Century Skills and Proficiencies Fostered

- Visual literacy
- Technological literacy
- Effective use of real-world tools

Evidence of Impact:

Order of Evidence	Nature of Evidence	Strength of Evidence
First	Field-Based Practice, Testimonials, Action Research	Preliminary
Second	Summary or Review of Empirical Work	Good
	Non-Experimental, Quantitative	

Research stresses the importance of planning in the writing process: Expert writers appear to engage in more planning than novice or student writers (Flower, 1989), and student writers who evidence planning appear to write better than those who do not (U.S. Department of Education, 1999). Software tools like those described can also help students understand content prior to writing (Anderson-Inman and Ditson, 1999). Although this review did not turn up hard first-order evidence on these programs, there is good secondary evidence that if used to help students understand and organize what they know within the context of relevant, challenging writing tasks, these tools can facilitate the writing process.

WIER - Writers In Electronic Residence: www.wier.ca/~wier/wiertapmain.html

Program Description

WIER is a program based in Canada that allows students to share writing with and receive feedback from professional authors and other students. Miller (2000), a winner of the Golden Apple award for teaching excellence, describes the program in **"Wired Writers: Canada's Writers in Electronic Residence Program" (available online at http://www.readingonline.org/international/miller1/)** as follows:

> *"It uses Internet technologies, specifically computer conferencing, to bring professional writers into the classroom to share their expertise with students at all grade levels, from elementary through high school, across Canada. Students post original compositions, poems, short stories, and other forms of writing, which are read and commented on by highly regarded professional writers. Moreover, students post their commentaries on the works of other students. The advice given is used to revise the pieces, which in turn fosters writing growth."*

Value Added Through Technology

- Technology facilitates students' ability to revisit and revise their work.
- Technology enhances students' ability to communicate with and receive feedback from expert writers and other students.
- Technology promotes authentic purpose by enabling students to publish work.

Links to Best Practice

- Students write for authentic audiences.
- Students write for authentic purposes.
- Students exercise some choice over topic.
- Students collaborate and receive feedback.
- Students are given multiple opportunities to revise.

21st Century Skills or Proficiencies Fostered

- Self-directed learning
- Creativity
- Interactive communication
- Collaboration

Evidence of Impact:

Order of Evidence	Nature of Evidence	Strength of Evidence
First	Qualitative or Descriptive Research	Good

Based on structured interviews with students and teachers during site visits to a number of schools, Wideman et al. (1998) observed the following impacts of this program:

- Students took feedback very seriously, some working harder on compositions they knew would be seen by professional authors.

- Some students reported increased confidence in themselves as writers, and some pursued writing on their own time.
- Some students felt that their ability to view their own work, in part as a result of critiquing others', improved, and that they could see strengths/weaknesses of their writing more clearly.
- Students appeared to view writing more as a process and came to more readily accept and expect revision.

Monsters, Mondrian, and Me: www.pausd.palo-alto.ca.us/schoolsites/hays/MonMonMe/Monsters/Title.html

Program Description

This project, featured in The National Academy Press' landmark book, *How People Learn*, edited by Bransford et al. (2000), asks students to invent and draw a monster, which they then describe over e-mail to students in other classrooms. The purpose of the exercise is to describe, in writing, a monster clearly enough and with enough detail that the other class can re-produce it without seeing the original drawing. This process is then repeated with abstract art, as in the style of Mondrian, then again with self-portraits (hence, the project title). After exchanging written descriptions, followed by exchanging drawings, students reflect on what aspects of their written descriptions might have been improved. Bransford and colleagues (2000) write,

> *"By giving students a distant audience for their writing...the project made it necessary for students to say everything in writing, without the gestures and oral communication that could supplement written messages within their own classroom. The pictures that their partners created on the basis of their written descriptions gave these young authors tangible feedback regarding the completeness and clarity of their writing....The electronic technologies that students used in this project were quite simple (word processors, e-mail, scanners). The project's sophistication lies more in its structure, which required students to focus on issues of audience understanding and to make translations across different media (words and pictures), potentially increasing their understanding of the strengths and weaknesses of each."* (p. 211)

Value Added Through Technology

- Communication technologies are used to enhance collaboration among students from different schools.

Links to Best Practice

- Students write for authentic audiences.
- Students have opportunities to collaborate, reflect on feedback, and incorporate feedback.

21st Century Skills and Proficiencies Fostered

- Visual literacy
- Technological literacy
- Interactive communication
- Collaboration

Evidence of Impact:

Order of Evidence	Nature of Evidence	Strength of Evidence
First	Summary or Review of Empirical Work	Preliminary
Second	Summary or Review of Empirical Work	Preliminary

According to Bransford et al. (2000), feedback provided to students during this process plays an important role in helping them develop an awareness of their audience and the way that the audience might respond to their text. They write that pictures produced by writing partners provides "tangible feedback regarding the completeness and clarity of their writing" (p. 211). As a result, student reflections suggest the development of awareness about aspects of writing that may have been sources for miscommunication. To illustrate, the authors provide examples of such student reflections:

> Says one young student: *"The only thing that made it not exactly perfect was our mistake.... We said, 'Each square is down a bit.' What we should have said was, 'Each square is all the way inside the one before it,' or something like that."* (p. 211)

This degree of awareness about the impact writing can have on the reader is impressive in an elementary aged student. Furthermore, related evidence on the benefits of collaborative interaction among distant students has been found in other projects as well. MacArthur (1996), for example, writes about a cross-national program conceived by Margaret Riel and colleagues where students from California, Israel, and Alaska collaboratively produced an electronic newspaper. The author found that when collaboration occurred between Israeli and American students,

essays written for peers were more explicit and detailed (and, therefore, scored higher) than essays written by students for their teachers.

Western Pennsylvania Writing Project: www.pitt.edu/~wpwp/index.html

Program Description

The National Writing Project or NWP, available at www.writingproject.org/index.html, serves as the "parent" to many regional writing projects throughout the country. As such, the NWP is a large teacher professional development effort focused on the teaching of writing. Teachers who participate in this effort work on a number of writing-related issues suggested by other teachers, and part of the process includes developing their own writing skills. The project has had a demonstrable impact on student writing skills.

Teachers participating in the NWP, as part of a course on developing the writing process with their students, have found interesting ways to integrate technology—ways that support their larger instructional goals. For instance, as part of the Western Pennsylvania Writing Project, Elaine Ware and Karen Murar (1998) began a collaborative discussion on literary works between high school and college students. They write: "We developed the idea for bridging the two schools [Gateway High School and Indiana University of Pennsylvania] to make students feel that they were part of a wider community of readers and writers" (Ware and Murar, 1998, p. 23).

Students at each school began an online discussion of the play *Fences* with students from the other school; teachers did not take part in this interaction, but rather let students decide what aspects of the work interested them and allowed students to analyze those aspects with their online partners. After a period of e-mail-based discussions, the classes independently discussed the play.

Value Added Through Technology

- Communication technologies are used to enhance collaboration among students across grade-levels and schools.

Links to Best Practice

- Writing tasks are rooted deeply in meaningful content that students have a chance to explore.
- Students write for authentic audiences.
- Students exercise some choice over topic.

21st Century Skills and Proficiencies Fostered

- Self-direction
- Interactive communication
- Collaboration
- Higher-order thinking
- Risk taking

Evidence of Impact:

Order of Evidence	Nature of Evidence	Strength of Evidence
First	Field-Based Practice, Testimonial, Action Research	Preliminary

Ware and Murar (1998) state that, "Since the teachers were not the primary audience, students adapted their language and use of e-mail technology to suit peers." They go on to say, "While many students realized the need to explain and support their statements, others learned this lesson from their e-mail partners who requested clarification.... In the classroom students might become defensive when asked to clarify their statements, but in the context of e-mail, students accepted such requests as a normal part of interpersonal communication" (p. 25).

The teachers also observed benefits to the way students were reading plays. For instance, they began predicting outcomes because they were reading the works more closely, asking questions of each other they might not have asked in a teacher-led discussion. According to Ware and Murar (1998), "Students engage in honest question-and-answer dialogue with a small group in a supportive social milieu. E-mail promotes risk-taking as students experience the metamorphic process of shaping ideas through dialogue" (p. 25).

CSILE - Computer-Supported Intentional Learning Environments:
www.ed.gov/pubs/EdReformStudies/EdTech/csile.html

Program Description

Computer-Supported Intentional Learning Environments (CSILE) scaffolds the writing process at the level of finding, organizing, and developing one's argument or message. Developed by researchers Scardamalia and Bereiter at the Ontario Institute for Studies in Education, CSILE allows students to collaboratively research and answer specific, high-level questions. Students collaboratively build an electronic database of information that is shared among all learners involved in a project; they also receive feedback from and provide feedback to their

peers. CSILE software scaffolds students' thinking during this process by providing prompts that encourage reflection, goal setting, and other thinking processes. CSILE can impact students' writing processes at three levels:

1. By giving them opportunities to write, both as they build databases and as they respond to others within the database.
2. By providing students with opportunities to reflect on what they have written—sometimes as a result of comments and feedback they receive from their peers, and sometimes as a result of the prompts built into the program.
3. By helping students discover and expand upon content they know or need to know.

Value Added Through Technology

- Communication technologies are used to enhance collaboration among students from different classes, grades, or schools.
- Technology facilitates the maintenance and sharing of the database students use.
- Technology facilitates research of content.

Links to Best Practice

- Students write for authentic audiences.
- Students write for authentic purposes.
- Writing is rooted in content, and students work on understanding and mastering that content.
- Students collaborate with others and have opportunities to incorporate feedback.
- Higher-level cognitive activities are scaffolded.

21st Century Skills and Proficiencies Fostered

- Self-directed learning
- Higher-order thinking
- Information literacy
- Interactive communication
- Collaboration

Evidence of Impact:

Order of Evidence	Nature of Evidence	Strength of Evidence
First	Summary or Review of Empirical Work	Strong

Bruer (1993) writes that students who are experienced with CSILE improve in their writing relative to other children. In his review, he reports that CSILE students tend to use more mental state and rhetorical words like "wonder," "understand," or "explain," suggesting that there is growth in students' metacognitive awareness. Furthermore, Bruer (1993) states that, "[Student] writing indicates that they are aware of what they know, what they don't know and what they must do to reach their learning goals. The rhetorical words are those that often refer to uses of language and to discourse elements in writing—words that usually appear in the plans of mature, expert writers.... CSILE students write well-constructed essays which contain some mature text conventions, whereas typically elementary students rely on straightforward knowledge telling." (p. 253)

Researcher John Schacter (1999), summarizes Scardamalia and Bereiter's findings in a review published by the Milken Exchange, identifying that CSILE students outperform control-group students on measures of understanding, reflection, and reading.

Convince Me: www.soe.berkeley.edu/~schank/convinceme/

Program Description

The Echo Educational Project at the University of California at Berkeley developed *Convince Me* to help students evaluate and develop their arguments. According to Christina Diehl (2001), whose doctoral dissertation examined the impacts of various uses of "Convince Me," the program "[breaks] down the process of building an argument into steps that identify hypotheses and evidence, as well as the explanatory and contradictory relationships that join them" (p. 35). Students generate arguments, rate the plausibility of those arguments, and then run a simulation which predicts which arguments should be accepted or rejected.

While the program was designed in the context of helping students with their scientific argumentation skills, research suggests that improved performance on essay writing might be an additional benefit, since the program helps students develop and articulate their ideas about a topic.

Value Added Through Technology

- Technology is used to scaffold students' generation of arguments, and later their evaluation of those arguments.

Links to Best Practice

- Higher-level cognitive processes are scaffolded.

21st Century Skills and Proficiencies Fostered

- Self-directed learning
- Higher-order thinking

Evidence of Impact:

Order of Evidence	Nature of Evidence	Strength of Evidence
First	Experimental or Quasi-Experimental	Preliminary

Diehl (2001) examined how well students who did and did not use the software for a science unit performed on an essay assignment. Students' teachers rated essays on how well they developed point of view, supported claims with evidence, and discussed the unit content. Control group students scored significantly lower on the essay task than students who worked with the "Convince Me" software. These data are suggestive, though not conclusive, in that alternative explanations for the findings cannot be ruled out.[1]

Calibrated Peer Review™ (CPR): www.molsci.ucla.edu/presentations/bcce_final/index.htm

Program Description

CPR is a Web-delivered software program designed by UCLA's Molecular Science Project (Fiore, 1998). Students are given some form of learning assignment, such as exploring a simulation of scientific principles, reading a chapter from their text, or conducting a lab experiment. They then respond to an essay question about their learning task. After submitting their response, students "practice" evaluating writing samples using a set of guiding questions that provide them with explicit criteria by which to gauge the quality of the sample. Following this, they are given opportunities to see how their instructor might have evaluated the same samples using the

same criteria (i.e. they "calibrate" their reviews to that of their instructor). In the final stages of this process, students evaluate the writing of peers in their class (or in other classes) and then evaluate their own original text submissions. The CPR program provides each student with their scores as a writer (based on peer reviews) and a reviewer (based on their responses to the calibration), as well as specific ratings by peers on evaluation criteria. Although CPR was developed in the context of teaching science, its developers stress that the program can be used across subjects and grade levels.

CPR is promising because it offers students opportunities to: (a) evaluate others' writing based on specific criteria, (b) reflect on their own writing after evaluating others' work. Furthermore, thetied to explorations of content; thus students write about issues that are meaningful in light of what they are learning for class.

It is important to note that CPR's utility depends a great deal on the quality of evaluation criteria that students use during the calibration phase; it is critical that these criteria focus on qualities that are meaningful in determining the merits of students' work. Moreover, although the program does not require students to revise their own texts, instructors may wish to add this component to the process. Doing so would encourage students to pay close attention to peer evaluations (and by extension to more truly collaborate with peers) as they use this feedback to develop their writing.

Value Added Through Technology

- Technology is used to share written products among students.
- Technology is used to manage high volumes of student data, including students' evaluations of their peer work.

Links to Best Practice

- Writing tasks are deeply rooted in meaningful content that students have a chance to explore.

21st Century Skills and Proficiencies Fostered

- Scientific literacy
- Information literacy

Evidence of Impact:

Order of	Strength of

Evidence	Nature of Evidence	Evidence
First	Experimental or Quasi-Experimental	Preliminary

Nancy Pelaez (2001) reports that when students in a college-level Human Physiology course used CPR to learn course content, their midterm essays scores were significantly higher than when students engaged in more traditional—lecture and cooperative group work—learning. However, these findings did not hold up for student final essay exams.[2] Furthermore, more than one explanation might account for the data.[2] Consequently, these findings should not be considered conclusive.

Teaching Writing Through the iEARN Global Community: www.iearn.org/projects/index.html

Program Description

Elementary school teacher Kristi Rennebohm Franz has integrated technology into many facets of her writing-process work with students. Franz, as part of her work within the iEARN (International Education and Resource Network, 2003) community, uses e-mail, the Web, and video to work on writing in the context of teaching science, social studies, math, and other subjects. Franz (2002) writes:

> *"The primary children in our classroom develop their written communication skills with global peers on topics such as comparing and contrasting local water habitats, quilt math and economic concepts, studies of geographic locations, and community cultures around the world....Written communication is also generated in the process of exchanging artwork with one another on curricular topics and then responding online to one another's drawings and paintings....Using word processing and e-mail software, [students] learn to draft, revise, edit, publish, and send their iEARN e-mail messages." (p. 1)*

Teachers can join a number of iEARN projects that address many different topics. These projects offer students opportunities to collaborate with peers in different cultures as they work on content that has real-world relevance. They also allow students to publish their work in some form. According to the project Web site (iEARN, 2003), "All iEARN projects involve a final 'product' or exhibition of the learning that has taken place as part of the collaboration. These have included magazines, creative writing anthologies, Web sites, letter-writing campaigns, reports to government officials, arts exhibits, workshops, performances, charity fundraising, and many more examples of youth taking action as part of what they are learning in the classroom."

Value Added Through Technology

- Communication technologies are used to enhance collaboration among students from different communities.
- Technology enables students to publish their work online, increasing the authenticity of the task.
- Technology is used to study and generate content that students use as the basis for their writing.

Links to Best Practice

- Students learn the value of and engage in writing as a process, including planning and revision across multiple drafts.
- Students write for authentic audiences.
- Students write for authentic purposes.
- Writing is rooted in content, and students work on understanding and mastering that content.
- Students collaborate with others and have opportunities to incorporate feedback.

21st Century Skills and Proficiencies Fostered

- Creativity
- Interactive communication
- Collaboration
- Effective use of real-world tools
- Global awareness
- Cultural literacy

Evidence of Impact:

Order of Evidence	Nature of Evidence	Strength of Evidence
First	Field-Based Practice, Testimonials, Action Research	Preliminary
	Non-Experimental, Quantitative	
Second	Summary or Review of Empirical Work	Preliminary

Franz (2002) observes that her students are more engaged and more reflective about their work as a result of participating in this global community of writers. "They are eager to participate in online communication with global peers and embrace writing as something they 'can do,'" she says (p. 3). These practices are further supported by research demonstrating the importance of task and audience authenticity (Newmann et al., 2001; MacArthur, 1996).

Learning Disabilities and Technology Project: www.cwu.edu/~setc/ldtech/

Program Description

Recently, the Special Education Technology Center at Central Washington University, in collaboration with a number of school districts and the RMC Research Corporation, launched the Learning Disabilities and Technology Project. The project provides teachers and their learning disabled students with training in the use of technology to support writing processes and instruction. Teachers learn to use various hardware and software tools including Inspiration, WYNN (an assistive reading/writing software that can be used to read text out loud), and Co:Writer® (a word prediction software that uses the first few keystrokes to predict what the student is attempting to type) as means of supporting process-based writing instruction. Students further learn to mentor their peers in mainstream classrooms on the same uses of technology.

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Value Added Through Technology

- Technology is used to circumvent keyboarding and spelling problems that may hamper the ability of special needs students to focus on content.
- Digital audio features are used to link the spoken and written word for students who may have difficulty.

Links to Best Practice

- Students are given the opportunity to focus on content rather than on the mechanics of writing.

21st Century Skills and Proficiencies Fostered

- Collaboration
- Technological literacy

Evidence of Impact:

Order of Evidence	Nature of Evidence	Strength of Evidence
First	Experimental or Quasi-Experimental	Preliminary

An evaluation of this program has shown that students in the program make greater gains than control-group students, particularly on a measure of content, style, and organization (RMC Research Corporation, 2002). However, the findings are categorized as preliminary because some aspects of the methodology, particularly about the selection of control and experimental students, are not explicitly discussed in the report.

Clicker: www.cricksoft.com/us/clicker_products/index.htm?href=/us/clicker_products/clicker4/index.htm

Program Description

Burns (2002) in an action research report entitled *How Can the Use of a Multimedia Authoring Program Facilitate the Implementation of the Process Approach for Second Language Writing* describes how she uses a software program called "Clicker" to support the process writing of students just beginning to write in Gaelic. "Clicker "software allows teachers and students to construct grids of pictures or words that students then use to compose text. In lieu of typing words letter-by-letter, as one must in most word-processing programs, students click on words or pictures in the grid to compose their texts. The program circumvents the keyboarding and spelling difficulties with which beginning writers often grapple when they use traditional word-processing tools. As a result, students can focus their attention on content. Clicker also includes an audio feature that allows students to hear what they have written (or to hear words that are in their word grids), a feature that can further support students' efforts at learning to write.

Burns uses Clicker in conjunction with other technology to support many aspects of the writing process. As a prewriting activity, students use Clicker to brainstorm on a topic and create Clicker grids that include words, phrases, and pictures that might be used for writing composition. Students also use scanners to integrate images into their texts; they e-mail letters drafted in Clicker to e-pals; and they use desktop publishing software to publish texts in a class magazine.

Value Added Through Technology

- Technology is used to circumvent keyboarding and spelling problems that may hamper young writers' ability to focus on content.

- Digital audio features are used to link the spoken and written word.

Links to Best Practice

- Students learn the value of and engage in writing as a process, particularly in planning.
- In the early part of the writing process, students can focus on content rather than on the mechanics of their work.

21st Century Skills and Proficiencies Fostered

- Technological literacy
- Basic literacy
- Visual literacy
- Collaboration

Evidence of Impact:

Order of Evidence	Nature of Evidence	Strength of Evidence
First	Field-Based Practice, Testimonials, Action Research	Preliminary

Burns (2002) also states that her students' attitudes about learning to write have been enhanced through the use of these technologies, and that students have become more aware of the importance of planning prior to writing. Furthermore, she states, "The amount of written material that the children produced and published throughout the year was unprecedented in our classroom."

Technology in Writing Assessment:

At the Advanced Learning Laboratory School (ALL School), Russell and Haney (1997) found that students who were accustomed to using computers for writing were at a disadvantage when asked to take writing assessments using paper and pencil. When these same tests were administered on computers, students' performance went up dramatically (Russell and Haney, 1997). In a subsequent white paper for the Secretary's Conference on Educational Technology, Russell (2000) suggested that a possible solution to this issue might be to give students a choice in how they complete an assessment. Russell (2000) reports that schools in Alberta, Canada are

following this practice—and that the percent of students opting to take assessments on computers just about quadrupled from 1996 to 2000.

Footnotes:

[1]For instance, it is not clear from the report whether the teacher who scored essays rated them blind to students' assignment to control or experimental conditions. It is possible that the teacher, knowing which students were and were not using the software, may have graded experimental condition essays more favorably. Furthermore, although the control and experimental groups were no different in their scientific reasoning abilities at the onset of the study, researchers did not examine whether the groups differed in their writing ability; thus it is possible that the control group condition may have been composed of weaker writers.

[2]Though students' multiple-choice exam scores for both midterm and final exams were higher when they used CPR than when they participated in more traditional learning formats.

[3]For instance, whereas traditional instruction included lecture, CPR lessons included problem-based tasks and no lecture. Thus it is not clear whether CPR, problem-based tasks, or both account for the gains observed. Furthermore, it is likely that CPR units took longer to complete than traditional units (this information is not reported); thus amount of time spent on task might also account for these results

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Section Six: Future Directions for Technology and the Teaching of Writing

We have demonstrated how current technologies can impact the written product as well as the writing process. In this section, we describe how *emerging* trends in technology and education can further impact teaching and learning to write.

There has been a recent wave of initiatives in this country that provide students with one-to-one access to laptops. For instance, Henrico County Public Schools in Virginia has opted to provide each middle and high school student in the district with laptops. The state of Maine is to launch a similar program for every seventh grader in the fall of 2002, and for every eighth grader in the fall of 2003. These programs, which allow students temporary "ownership" of the technology, can have significant impact on the way teachers go about the job of teaching. To begin with, computer-supported assignments and projects are no longer limited to the school day; students can count on having access to the same tools at home as they have in school. Full-time access also means that writing projects can more easily incorporate collaboration and feedback among teachers and students. Finally, students—in the context of e-mail, instant-messaging, and other communication technologies—will most likely make writing an activity that they engage in regularly and for purposes that are inherently motivating.

A second important trend suggests that technology has made access to experts in the field a real possibility. As we demonstrated in Section Five, interaction with experts can legitimize the writing-revising process for students. As that section illustrated, feedback from "real" writers can be a powerful motivator for students.

Third, as Allen Glenn (2002) stated in a speech at the 2002 Preparing Tomorrow's Teachers to Use Technology

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(PT3) conference, the World Wide Web is no longer something that students simply "consume." Rather, students today can contribute their own voices to the Web, to be seen and heard by anyone, anywhere. The sheer number of online student publications attests to this shift. As a result, students have highly legitimate, public forums for voicing their ideas and work. iEARN's *The Contemporary*, which is available on the Web at www.iearn.org/projects/tc.html, is one such magazine on national and international issues. Likewise, *The Link*, which is available online at www.co-nect.com/Schools/Webzine/, is a student-produced magazine by Co-Nect. A third student-produced magazine entitled *An End to Intolerance*, which is available online at www.iearn.org/hgp/aeti/student-magazine.html, deals with human rights. One student editor is quoted on the site as saying, "*An End to Intolerance* is one of the ways students can 'continue the Holocaust/Genocide Project's (HPG) goal of spreading information, promoting respect for human rights, and ending the hate that surrounds intolerance'" (Johnson, 1995). Clearly this kind of work can have great personal meaning for students—both in terms of building their awareness of important social and political issues, and in contributing to a belief that they can produce something that has real value beyond the classroom.

Finally, the emergence of digital imaging technologies has rendered such imagery accessible to the masses. Students growing up in this highly visual world now have access to powerful digital images at low cost. As a result, they can capitalize on these technologies to reinvent the shape (and power) of their messages—in much the same way as magazine editors, advertising executives, or Web designers have.

In the context of writing programs that: emphasize the writing process, encourage students to share and revisit their work, and present authentic opportunities for writing, these trends can revolutionize writing teaching and learning.

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Endnotes

1) See, for example, the National Council of Teachers of English (NCTE) English Language Arts Standards (www.ncte.org/standards/standards.shtml); these repeatedly reference students' ability to communicate with various audiences.

2) Authentic tasks, according to these authors, have the following qualities: They allow for a) the construction of knowledge (i.e., students must actually organize, interpret, synthesize, evaluate, or apply information); b) disciplined inquiry (i.e., students must apply a relevant knowledge base of facts, vocabularies, and theories to developing an understanding of the subject that is deep rather than superficial); and c) value beyond school (i.e., the results of students' work should have "utilitarian, aesthetic, or personal value)" (Newmann et al., 2001, p. 15).

3) According to Barbara Storms, Ed.D, associate professor at California State University, Hayward (personal communication, July 30 and 31, 2002), the final report from this study is pending release by the National Center for Education Statistics (NCES).

4) Because many of the studies cited in this review were published in the 1980s, it is difficult to extrapolate from this work to classrooms and students today. In one sense, these studies likely underestimate the ways in which technology can be used to facilitate the teaching of writing because of increased capabilities of technology as well as increased usability of many hardware and software features (see subsequent sections). At the same time, the effects of novelty or attitude on these findings might have been higher two decades ago as student access to computers was rarer than it is today.

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5) Such proficiencies, which are increasingly being called for by leaders in business and education (see for example, the Secretary's Commission on Achieving Necessary Skills, or SCANS, 2000 report) are described in NCREL and Metiri Group's *enGauge® 21st Century Skills* framework, available online at www.ncrel.org/engauge/skills/skills.htm.

6) Cochran-Smith (1991) makes this point about the impact of word processors on writing; however, it can be generalized to all uses of technology in support of effective teaching and learning.

7) This review does not claim to be comprehensive; thus, there may be evidence on these programs that was not considered here.

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